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### (54) Method for fabrication of probe

(57) A method for fabrication of a probe, comprising the steps of: (1) forming a structure wherein a contact part formed on one side of an insulating flexible substrate and a conductor formed on either side or inside of said flexible substrate are electrically continued, and (2) joining said flexible substrate and a frame rigid substrate capable of supporting the tension in the planar direction of said flexible substrate at the outer periphery thereof, by bonding them by lamination press after heating, or by heating after lamination press, thereby applying a planar tension to the flexible substrate enclosed by the rigid substrate. According to the present invention, a method for fabrication of a probe can be provided, which probe serving well for use at high temperatures, such as for burn-in test, with high contact reliability, and being superior in durability as a test tool.

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**Description****FIELD OF THE INVENTION**

The present invention relates to a method for fabrication of sheet probe structures (hereinafter "probe") for determination of various electric performances and circuit testing, particularly testing at high temperatures such as burn-in test, of small test objects.

**BACKGROUND OF THE INVENTION**

Along with the development of miniaturized and multifunction electronic equipments in recent years, semiconductor elements to be mounted thereon have been desired to be smaller in size, and the mounting area of the semiconductor element has been demanded to be minimized to the greatest possible extent. In response, a bare chip mounting has been employed, wherein semiconductor elements after formation in plurality on a silicon wafer or upon parting in smaller units (hereinafter semiconductor elements in this stage are to be referred to as bare chips) are mounted without packaging. This mode of mounting is considered to prevail rapidly. Even mounting with a wafer will be practiced soon. Therefore, various quality determinations and testing of semiconductor elements, particularly testing at high temperatures such as burn-in test, should be conducted on bare chips or pre-bare chip, i.e. on-wafer, stage products.

While small test objects such as bare chips and wafers contain elaborately formed contact targets such as electrodes and conductors, electric contact is most preferably made by a sheet probe. Such sheet probe generally contains a contact part formed on one side of an insulating flexible substrate and a circuit pattern formed on either side or inside of said flexible substrate, the two being electrically continued. The contact part is a point where electric contact is made with respect to its contact target, and is generally a protruding good metal conductor called a bump contact, or simply a bump.

When subjected to a burn-in test generally performed at about 120-150°C, sometimes at about 200°C, a probe manufactured by a conventional method is susceptible to a contact failure or checkout failure as a result of dislocation of bump contact of the probe after temperature rise, though the bump contact was originally in contact with the contact target on a test object at room temperature when the test was started, due to significantly different coefficients of linear expansion between the test object and the probe, thereby impairing the reliability of the probe as a test tool.

Even when the dislocation of the bump contact of the probe is not so great as to miss the contact target, the bump contact drawn for several dozens of microns while being in contact with the contact object causes flaw on the contact target and degrades its product value, or conversely, the bump contact may be damaged by the contact target to shorten its service life as a

test tool.

It is therefore an object of the present invention to solve the above-mentioned problems and provide a method for fabrication of a probe which serves well for use at high temperatures, such as in burn-in test, with high contact reliability, and which is superior in durability as a test tool.

**SUMMARY OF THE INVENTION**

The fabrication method of the present invention is characterized by a step (1) for forming a structure wherein a contact part formed on one side of an insulating flexible substrate and a conductor formed on either side or inside of said flexible substrate are electrically continued, and a step (2) for joining said flexible substrate and a frame rigid substrate capable of supporting a tension in the planar direction of said flexible substrate at the outer periphery thereof, by bonding them by lamination press after heating, or by heating after lamination press, thereby applying a planar tension to the flexible substrate enclosed by the rigid substrate.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1(a), Fig. 1(b) and Fig. 1(c) schematically show one example of fabrication of the probe of the present invention.

Fig. 2(a), Fig. 2(b) and Fig. 2(c) schematically show one preferable method for applying a tension as a result of contraction of the flexible substrate.

Fig. 3 shows one example of the rigid substrate to be used in the present invention.

Fig. 4(a), Fig. 4(b) and Fig. 4(c) show one example of the probe manufactured by the present invention.

Fig. 5(d), Fig. 5(e) and Fig. 5(f) show another example of the probe manufactured by the present invention.

**DETAILED DESCRIPTION OF THE INVENTION**

In the present invention, an important step is to bond a rigid frame substrate to the flexible substrate by the use of heating and lamination press, thereby to apply a tension on the flexible substrate. This enables fabrication of a probe wherein the flexible substrate is stretched relative to the rigid frame substrate. The tension is generally a difference in the amount of expansion between the rigid substrate and the flexible substrate, or difference in the amount of shrinkage upon heating, as detailedly described in the following (1) and (2).

(1) When a material showing a greater thermal expansion than the rigid substrate is used as a material for the flexible substrate, the flexible substrate and the rigid substrate are heated first to cause expansion, and then bonded by lamination press. By cooling to room temperature from this state, the flexible substrate shrinks more greatly than the rigid substrate, and causes occurrence of

tension. The rigid substrate does not necessarily expand by heating, but may shrink. The junction between the flexible substrate and the rigid substrate may become complete simultaneously with lamination press, or by cooling after lamination press, or may require some time thereafter. The lamination press is preferably maintained at least until the bonding becomes complete.

(2) When a material showing a greater thermal shrinkage than the rigid substrate is used as a material for the flexible substrate, said material being incapable of restoring its original size by lowering the temperature after shrinkage, the flexible substrate and the rigid substrate are bonded by lamination press before heating, and then heated to the shrinkage temperature. By this method, the tension occurred upon heating remains even after cooling the substrates to room temperature. Again, the lamination press is preferably maintained at least until the bonding becomes complete.

By preparing a probe by the method (1) or (2) as mentioned above, the flexible substrate can be easily and preferably stretched relative to the rigid frame substrate. The flexible substrate stretched relative to the rigid frame substrate is free of noticeable dislocation of the contact part of the probe from the contact target, even under expansion at high temperatures such as in burn-in test, since variation in the amount of expansion is absorbed by variation in tension thus imparted.

In either (1) or (2) above, a material showing expansion at a temperature higher than 200°C or a material adapted to shrink at a temperature higher than 200°C is preferably used for both the flexible substrate and rigid substrate, and the substrates are heated and bonded by lamination press. The above-mentioned effect can be achieved in a burn-in test as well, wherein the temperature reaches 200°C, by preparing the substrates under the above conditions of fabrication.

Conversely, the linear expansion coefficient of the material used for the rigid substrate is suitably determined to intentionally cause relative dislocation of the contact target to a desired extent from probe contact part. A certain combination of the probe and test substrate results in penetration of an oxide film formed on the surface of the contact target, thus ensuring more preferable contact performance.

In Fig. 1 showing one example of the fabrication method of the present invention, the conductor is a circuit pattern, and bump contacts are formed at the end of the fabrication process. This Figure shows a section of a product and only the lines visible in the section.

Fig. (a) is a step for forming a circuit pattern 2 (conductor) on a flexible substrate 1.

Fig. (b) is a step for joining the flexible substrate 1 and a rigid substrate 3 by heating and lamination press to apply a tension to the flexible substrate. In this embodiment, an adhesive layer 5 is interposed. As mentioned in the above with respect to the effect, when

a material showing a greater thermal expansion than the rigid substrate is used as a material for the flexible substrate, the flexible substrate and the rigid substrate are heated first to cause expansion, and then bonded by lamination press. When a material showing a greater thermal shrinkage than the rigid substrate is used as a material for the flexible substrate, the flexible substrate and the rigid substrate are bonded by lamination press before heating, and then heated to the shrinkage temperature and joined.

Fig. 1(c) is a step for forming a bump contact 4 which becomes a contact part.

The material used for the flexible substrate may be any as long as it has electric insulating property and flexibility and shows greater expansion or shrinkage than rigid substrate upon heating.

Specific examples of the material which expands by heating include polyester resin, epoxy resin, urethane resin, polystyrene resin, polyethylene resin, polyamide resin, polyimide resin, ABS resin, polycarbonate resin, silicone resin, fluororesin and the like, which may be thermosetting or thermoplastic. Particularly preferred is polyimide resin which still expands even at a temperature higher than 200°C and shows superior insulating property.

Of the materials for the flexible substrate, a suitable material which shrinks upon heating is, for example, a material having a glass transition temperature which is higher than atmospheric temperature, and which has undergone drawing treatment at ambient temperature. Such material shrinks by heating to the glass transition temperature as a result of the release of a stress. In particular, one having a glass transition temperature higher than 200°C can stand burn-in tests at high temperatures and is preferably used.

A tension can be applied to a flexible substrate prepared from a thermosetting resin which shrinks with progression of curing, by maintaining the semi-cured state of the resin material, and heating, after bonding the substrate to a rigid substrate by lamination press, to a complete curing of the resin, thereby giving a tension by shrinkage. Alternatively, a resin containing a solvent is heated to a temperature higher than the boiling point of the solvent to evaporate said solvent, and the flexible substrate is allowed to shrink, thereby to apply a tension.

The method schematically shown in Fig. 2 may be preferably used for applying a tension as a result of shrinkage of the flexible substrate.

As shown in Fig. 2(a), a polyimide precursor is applied to a plate metal foil (e.g., copper foil) 2a to be a conductor, and heated to evaporate the solvent and cure polyimide, whereby a laminate of metal foil and flexible substrate 1 is obtained. In so doing, the flexible substrate tends to shrink with the progress of curing of polyimide, but is hindered by the metal foil and leaves a residual stress inside the flexible substrate, which stress being directed toward shrinkage. A rigid substrate 3 is bonded to this laminate by heating. In this embodiment,

an adhesive layer 5 is interposed as in Fig. 1. It is preferable that the rigid substrate be heated at a temperature higher than the glass transition temperature for bonding and the residual stress in the flexible substrate which is directed toward shrinkage be made greater.

Then, a bump contact is formed at a predetermined position on the flexible substrate, as shown in Fig. 2(b).

Finally, as shown in Fig. 2(c), the metal foil is partly removed and subdivided in the planar direction to form a circuit pattern, whereby obstacle for shrinking is removed and the residual stress is completely released. By the complete release of the stress, the flexible substrate shrinks and a tension is applied to the flexible substrate to give the probe of the present invention.

In this embodiment, however, it is preferable that the amount of shrinkage produced by the progress of curing of polyimide which is the material of the flexible substrate be greater than that produced when the metal foil is cooled after heating.

When the conductor is a circuit pattern, the conductor is formed such that it corresponds to the position where the bump contact is to be formed, and any desired number of circuits independent from each other may be formed. In other words, the mode of circuit pattern is arbitrarily selected from the options comprising a circuit pattern corresponding to respective bump contacts and independent from other circuit patterns, a single conductor layer wherein the entire part is electrically continued, and the like. Said circuit pattern becomes a conductor to connect bump contacts with external circuits, such as a connection at the outer periphery of said probe.

Alternatively, the conductor itself may become a bump contact, wherein the flexible substrate has bump contacts on both sides.

When the conductor is a circuit pattern, the material thereof is preferably copper, nickel, solder, gold, silver, alloys such as alloy 42 and phosphorus-bronze, and the like.

The circuit pattern may be formed by a known method such as subtractive method and additive method. The subtractive method leaves only circuit patterns by etching a laminate of substrate and conductor. The additive method includes directly drawing a circuit pattern on the substrate by evaporation and the like.

A circuit pattern is formed inside of the flexible substrate by forming a circuit pattern on a flexible substrate to be a base by the above-mentioned method, and coating same with a material having flexibility and insulating property. In this case, the material used for the flexible substrate to be the base and the material to be used for the coating may be the same or different.

The rigid substrate may be any as long as it can support the tension in the planar direction (plane extending direction) to be applied to the flexible substrate.

When the test substrate is an integrated circuit, since the general linear expansion coefficient of silicon in a temperature range of 0-200°C is about 3.5 ppm, a

linear expansion coefficient of the rigid substrate in this temperature range of 1-8 ppm provides a preferable outer frame for stretching a flexible substrate, which frame being subject to less dimensional changes relative to the test substrate.

When elimination of locational difference between bump contact and contact object is desired, the linear expansion coefficient of the rigid substrate is most preferably set to the linear expansion coefficient of the test substrate. Conversely, when the locational difference between bump contact and contact object is positively utilized, as discussed with regard to the effect above, a material having a suitable linear expansion coefficient relative to that of the test substrate is used.

The material of the rigid substrate is exemplified by ceramics such as alumina, silicon nitride and silicon carbide, alloys such as alloy 42, and the like.

While the shape of the rigid substrate is subject to no particular limitation as long as it is a frame, when the test substrate is a wafer, it is preferably a circular ring frame in view of the shape of the wafer which is a disc and uniformity of the tension. Fig. 3 is a perspective view showing a section of one embodiment thereof. In this embodiment, a rigid circular ring substrate 3 is used as a frame and a flexible substrate 1 is stretched thereon. In this Figure, a conductor 2 and a contact part 4 are both bump contacts.

The junction plane between the rigid frame substrate and the flexible substrate may be a continuous ring or an interrupted frame like a broken line, as long as the flexible substrate can be extended over the inner region enclosed by the frame.

Otherwise, the rigid frame substrate may have a shape identical with the outer shape of the test substrate, where the test substrate is retained and positioned by the outer shape of the test substrate.

The junction between the rigid frame substrate and the flexible substrate may be achieved by any method as long as it involves heating and lamination press. The method may be adhesion using an adhesive, lamination press using heat bonding, a method comprising sandwiching a flexible substrate between a pair of rigid substrates and joining them with a screw before or after heating, or other method.

When an adhesive is used for joining, the adhesive is particularly preferably one having heat resistance to stand the high temperature of burn-in test, such as polyimide adhesives.

The method for adhering is a general method wherein a liquid adhesive is applied onto the flexible substrate or rigid substrate before lamination press, followed by drying, or adhering an adhesive film. In addition, a flexible substrate having plural layers may be used and a thermoplastic polyimide is integrally laminated on the resin layer to be the base of the substrate and used as an adhesive layer, or the resin to be the base of the substrate may be formed from a thermoplastic polyimide and used as an adhesive layer.

Lamination press includes conventional steps. For

example, pressure is preferably continuously applied until the completion of the adhesion, from application of lamination heat to cooling.

The contact part may be any as long as it can be electrically connected to the contact target of the test substrate. In general, it has a protrusion of bump contact (or simply bump) of good conductor metal. The contact part may not necessarily protrude from the flexible substrate surface, and may form the same plane with the flexible substrate or may be a concave depending on the shape of the mating contact part. The bump contact is explained in the following.

The material of the bump contact is exemplified by gold, silver, copper, lead, chromium, zinc, aluminum, nickel, iron, platinum, palladium, rhodium, ruthenium and the like. The bump contact may be made from a single metal or may be a laminate of different metals. When a laminate of different metals is used, the outermost metal is preferably one having a Knoop hardness of 700-1200 Hk, such as rhodium and ruthenium.

While the bump contact is formed to make continuity with the conductor, the bump contact and conductor in a general probe are formed at the positions in the front/reverse or surface深深 layer relations with respect to the flexible substrate where the bump contact and conductor are positioned right below each other, and electrically continued through a through-hole formed in the flexible substrate. One example of configuration method of a bump contact having such continuity structure is schematically explained in the following.

As shown in Fig. 1(a), a conductor 2 is formed on either side of flexible substrate 1 or inside thereof. Then, as shown in Fig. 1(c), a through-hole is formed at the position of the conductor (when the conductor is formed inside of the substrate, the position precisely corresponding to the position right above), and the conductor is exposed at the bottom of the inside of the through-hole. Then, a good conductor metal to be the material of bump contact is deposited in the through-hole to fill the hole and allowed to deposit until it protrudes from the surface of the flexible substrate to form a bump contact 4, as shown in Fig. 1(c).

The through-hole is formed in the flexible substrate by wet etching comprising chemical etching using chemicals and solvents, or dry etching using laser (e.g., carbon dioxide gas laser, YAG laser and eximer laser), plasma and the like. When precise microhole forming processing is desired, etching using a laser is preferable.

The order of the processing steps shown in Fig. 1 is not fixed, and they may be performed in an optional order. For example, the steps of Fig. 1(a) and Fig. 1(c) may be performed first to complete a general probe, and then bonding of the flexible substrate and rigid substrate of Fig. 1(b) may be done as a final step.

When formation of a bump contact is the final step in the procedure of Fig. 1(a) - Fig. 1(c) and the rigid substrate is used as a positioning frame of the test substrate, the bump contact is preferably formed using the

rigid substrate as a reference position.

Other embodiments of the probe to be obtained by the present invention are shown in Fig. 4(a) - Fig. 4(c) and Fig. 5(d) - Fig. 5(f) wherein shown are only the lines visible in the section.

Fig. 4(a) has the same structure as Fig. 1 wherein a rigid substrate 3 is integrally formed on the outer periphery of the flexible substrate 1. B is a test substrate.

Fig. 4(b) shows a frame formed by making a concave in the center of the rigid substrate 3. In this concave, a compliance 6 is set.

Fig. 4(c) shows a bare chip test substrate B which is brought into contact with a solder bump contact. In this embodiment, since the contact target is a protrusion, the contact part 4 on the probe side is a lead, namely, a circuit pattern 2 exposed to give a small flat contact plane.

Fig. 5(d) shows a test substrate B which is the same as that in Fig. 4(c). In this embodiment, a rigid substrate 3 is formed on the test substrate side relative to the flexible substrate 1, and the through-hole in the center of the rigid substrate has a shape capable of retaining the test substrate by holding same at its outer periphery, which shape being used as an alignment hole for positioning the test substrate.

Fig. 5(e) shows a rigid substrate having a conductor circuit (not shown) inside of the substrate, and a connector 8 which can be connected to an outside equipment. A circuit pattern 2 of the flexible substrate and the conductor circuit inside the rigid substrate are connected via a conductive path 7.

Fig. 5(f) shows an embodiment wherein a rigid substrate is formed on the test substrate side, wherein the flexible substrate is a multi-layer circuit substrate.

The present invention is described more specifically in the following by way of illustrative embodiments.

#### Example 1

In this embodiment, a flexible substrate was made to shrink by heating the same for bonding to a rigid substrate.

#### Preparation of flexible substrate having a conductor layer

A polyimide precursor solution (solvent: NMP, N-methyl-2-pyrrolidone) was prepared by polymerization of *s*-biphenyltetracarboxylic dianhydride (100 moles) with 4,4'-diaminodiphenyl ether (30 moles) and *p*-phenylenediamine (70 moles). This solution was casted on a copper foil, dried, cured for imidation to give a flexible substrate having a conductor layer (a laminate of copper foil and polyimide film). The linear expansion coefficient of the substrate as a whole was 18 ppm, and that of polyimide film alone was 22 ppm. This polyimide film had a glass transition temperature in the vicinity of 285°C, and shrinkage was 0.6% after heating the film to 300°C.

Formation of circuit pattern

A photo resist was applied to the surface of the above-mentioned copper foil, and a predetermined circuit pattern was formed by exposure, developing, copper etching and resist peeling, which pattern being designed to precisely pass the position corresponding to the position where a bump contact was to be formed.

Formation of bump contact

A through-hole having an inner diameter of 80  $\mu\text{m}$  was formed in the polyimide film by irradiation of carbon dioxide gas laser by a mask projection+galvanoscanning method at the position where a bump contact was to be formed, whereby the circuit pattern was exposed at the bottom of the through-hole.

A resist membrane against plating was applied to the surface of the circuit pattern except the portion exposed at the bottom of the through-hole, and Ni was deposited in the through-hole by electroplating using the circuit pattern as a negative electrode to fill the hole. The electroplating was continued to form a protrusion having a height from the surface of the substrate of 20  $\mu\text{m}$ , and the protrusion was plated with gold in the thickness of 1  $\mu\text{m}$ , which was followed by rhodium plating in the thickness of 1  $\mu\text{m}$  and peeling of the resist membrane to give a probe part.

Bonding of flexible substrate and rigid substrate

A ring frame (outer diameter 240 mm, inner diameter 220 mm, thickness 1 mm) was formed from ceramic and used as a rigid substrate. The linear expansion coefficient was 7 ppm.

A polyimide adhesive film punched out into a frame product having the same shape with the rigid substrate was interposed between the rigid substrate and the flexible substrate and heated to 200°C. The laminate was bonded by lamination press in the laminating direction to give the probe of the present invention. The lamination conditions were 300°C  $\times$  1 hr and 50 kg/cm<sup>2</sup>. The pressure was continuously applied after heating until the completion of cooling.

Properties of probe

The flexible substrate of the probe thus stretched, which was enclosed by the rigid substrate, was in tension in the planar direction, and stretched uniformly relative to the rigid substrate.

The linear expansion coefficient of the probe at room temperature - 200°C was determined with respect to the portion of the flexible substrate in tension and found to be 4 ppm.

A 6 inch wafer as a test substrate was brought into close contact with the probe and subjected to a burn-in test at room temperature - 150°C. As a result, no trace of dislocation of bump was found at the contact part on

the wafer side, and no damage was found on the bump surface.

Example 2

5 In this embodiment, the same steps were involved as in Example 1 except that the circuit pattern was formed inside the flexible substrate, and sizes and materials of respective parts were different.

Formation of circuit pattern

In the same manner as in Example 1, a circuit pattern was formed on one side of a flexible substrate, and 15 covered with a polyimide coating except an outside contact terminal.

Formation of bump contact

20 A through-hole having an inner diameter of 30  $\mu\text{m}$  was formed in the polyimide film by irradiation of an excimer laser (wavelength 248 nm) by a mask projection method at the position where a bump contact was to be formed, whereby the circuit pattern was exposed at the bottom of the through-hole.

25 A resist membrane against plating was applied to the outside contact terminal of the circuit pattern, and Ni was deposited in the through-hole to fill the hole by electroplating using the circuit pattern as a negative electrode. The electroplating was continued to form a protrusion having a height from the surface of the substrate of 25  $\mu\text{m}$ , and the protrusion was plated with gold in the thickness of 1  $\mu\text{m}$ , which was followed by rhodium plating in the thickness of 1  $\mu\text{m}$  and peeling of the resist membrane to give a probe part.

Bonding of flexible substrate and rigid substrate

30 A rigid substrate made from alloy 42 and having an 40 opening of the size of the test substrate bare chip (outer size 12 mm  $\times$  7 mm) plus 5 mm circumferential gap was prepared to give a frame of outer size 40 mm  $\times$  40 mm and thickness 0.5 mm.

45 A polyimide adhesive film punched out into a frame product having the same shape with the rigid substrate was interposed between the rigid substrate and the flexible substrate, heated, and bonded by lamination press to give the probe of the present invention. The lamination conditions were 180°C  $\times$  1 hr and 50 kg/cm<sup>2</sup>. The pressure was continuously applied from initiation of heating to the completion of cooling.

Properties of probe

55 The flexible substrate of the probe thus obtained, which was enclosed by the rigid substrate, was in tension in the planar direction, and stretched uniformly relative to the rigid substrate.

The linear expansion coefficient of the probe at

room temperature - 200°C was determined with respect to the portion of the flexible substrate in tension and found to be 6.5 ppm.

A bare chip as a test substrate was brought into close contact with the probe and subjected to a burn-in cycle at room temperature - 125°C. As a result, no trace of dislocation of bump was found at the contact point on the bare chip side, and no damage was found on the bump surface.

### Example 3

In this embodiment, the flexible substrate was made to shrink by heating for joining the flexible substrate and the rigid substrate.

#### Preparation of flexible substrate having a conductor layer

A polyimide precursor solution (solvent: NMP, N-methyl-2-pyrrolidone) was prepared by polymerization of *s*-biphenyltetracarboxylic dianhydride (100 moles) with 4,4'-diaminodiphenyl ether (30 moles) and *p*-phenylenediamine (70 moles). This solution was casted on a copper foil, dried, cured for imidation to give a flexible substrate having a conductor layer (a laminate of copper foil and polyimide film).

The linear expansion coefficient of the substrate was 18 ppm and the dimensional shrinkage between before and after complete removal of the copper foil was 0.1%.

This polyimide film had a glass transition temperature in the vicinity of 285°C, and shrinkage was 0.6% after heating the film to 300°C.

#### Bonding of flexible substrate and rigid substrate

A polyimide adhesive film punched out into a frame product having the same shape with the rigid substrate was interposed between a flexible substrate and a ceramic frame formed in outer diameter 240 mm, inner diameter 220 mm and thickness 1 mm and having a linear expansion coefficient of 7 ppm, heated, and bonded by lamination press in the laminating direction to give the probe of the present invention.

The lamination conditions were 250°C × 1 hr and 50 kg/cm<sup>2</sup>. The pressure was continuously applied after heating until the completion of cooling.

#### Formation of circuit pattern

A photo resist was applied to the copper surface of the substrate. Exposure, developing, copper etching and resist peeling gave a predetermined circuit pattern.

#### Formation of bump contact

A through-hole reaching the copper foil was formed in the polyimide film at the predetermined position by

the irradiation of carbon dioxide gas laser by a mask projection+galvanoscanning method.

A resist against plating was applied to the opposite side of the copper foil from the polyimide film, and Ni was deposited to fill the through-hole by electroplating. A protrusion having a height of 30 µm was formed, and the protrusion was plated with gold in the thickness of 1 µm, which was followed by rhodium plating in the thickness of 1 µm.

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#### Shrinkage of flexible substrate by heating

The obtained substrate was again sandwiched between lamination presses and applied with a pressure. The substrate was heated to 300°C in this state, cooled to room temperature to make the flexible substrate shrink to apply a tension.

#### Properties of probe

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The linear expansion coefficient of the probe at room temperature - 200°C was determined with respect to the polyimide film and found to be 4 ppm.

A 6 inch wafer was brought into close contact with the probe and subjected to a burn-in cycle at room temperature - 150°C. As a result, no trace of dislocation of bump was found at the contact part on the wafer side, and no damage was found on the bump surface.

#### Example 4

In this embodiment, the flexible substrate was prohibited from shrinking by the presence of a conductor layer, but allowed to shrink in the final step by etching the conductor.

#### Formation of flexible substrate having a conductor layer

A polyimide precursor solution (solvent: NMP, N-methyl-2-pyrrolidone) was prepared by polymerization of pyromellitic dianhydride with 4,4'-diaminodiphenyl ether. This solution was casted on a copper foil, dried, cured for imidation to give a flexible substrate having a conductor layer (a laminate of copper foil and polyimide film). The linear expansion coefficient of the substrate was 20 ppm. The shrinkage was 0.4% between before and after complete removal of copper foil of the substrate by etching.

#### Bonding of flexible substrate and rigid substrate

A polyimide adhesive solution was applied to one side of a ceramic frame formed in outer diameter 240 mm, inner diameter 220 mm and thickness 1 mm and having a linear expansion coefficient of 7 ppm and dried. After heating the above-mentioned flexible substrate, the frame was bonded by lamination press. The lamination conditions were 250°C × 1 hr and 20 kg/cm<sup>2</sup>. The pressure was continuously applied after heating

until the completion of cooling.

#### Formation of bump contact

A through-hole reaching the copper foil was formed in the flexible substrate at the predetermined position by irradiation of an eximer laser (wavelength 248 nm) by a mask projection method. 5

A resist against plating was applied to the surface of the copper foil except the inside of the through-hole, and Ni and then gold were successively plated inside the through-hole by electroplating. A protrusion having a height of 20  $\mu\text{m}$  was formed, and the protrusion was plated with gold in the thickness of 1  $\mu\text{m}$ . 10

#### Formation of circuit pattern

The copper foil was all removed except the circuit pattern by alkali etching to release all shrinking stress which remained inside the flexible substrate and to allow the flexible substrate to shrink, whereby a desired probe was obtained. 20

#### Properties of probe

The linear expansion coefficient of the probe at room temperature - 200°C was determined and found to be 7 ppm. 25

A 6 inch wafer was brought into close contact with the probe and subjected to a burn-in cycle at room temperature - 150°C. As a result, no trace of dislocation of bump was found at the contact point on the wafer side, and no damage was found on the bump surface. 30

#### Comparative Example 1

In the same manner as in Example 2 except that a glass epoxy substrate was used instead of alloy 42 as a rigid substrate, a probe was obtained. The flexible substrate of the obtained probe was corrugated and free of stress. 35

A bare chip was brought into close contact with the probe and subjected to a burn-in cycle at room temperature - 125°C. As a result, a flaw caused by the bump which moved several dozen  $\mu\text{m}$  was found in the pad portion of the chip. 40

#### Claims

1. A method for fabrication of a probe, comprising the steps of: 50

(1) forming a structure wherein a contact part formed on one side of an insulating flexible substrate and a conductor formed on either side or inside of said flexible substrate are electrically continued, and 55

(2) joining said flexible substrate and a frame rigid substrate capable of supporting the ten-

sion in the planar direction of said flexible substrate at the outer periphery thereof, by bonding them by lamination press after heating, or by heating after lamination press, thereby applying a planar tension to the flexible substrate enclosed by the rigid substrate. 14

2. The method of claim 1, wherein the flexible substrate is made from a material showing a greater thermal expansion than the rigid substrate, and the flexible substrate and the rigid substrate are bonded by lamination press after heating. 15
3. The method of claim 1, wherein the flexible substrate and the rigid substrate are made from materials which still show an expansion even at a temperature higher than 200°C, and a temperature for heating the flexible substrate and the rigid substrate is higher than 200°C. 20
4. The method of claim 1, wherein the flexible substrate is made from a material showing a greater thermal shrinkage than the rigid substrate, and the flexible substrate and the rigid substrate are bonded by lamination press before heating. 25
5. The method of claim 4, wherein the flexible substrate is made from a material having a glass transition temperature of not less than 200°C and the flexible substrate is designed to shrink by heating at a temperature higher than said glass transition temperature. 30
6. The method of claim 4, wherein the conductor is a metal plate foil, and, after lamination press and heating of the flexible substrate and the rigid substrate, said metal foil is subdivided in the planar direction to form a circuit pattern. 35
7. The method of claim 1, wherein the material of the rigid substrate has a linear expansion coefficient which is the same as that of a test substrate of the probe. 40
8. The method of claim 1, wherein the shape of the rigid substrate is a frame having, at the center thereof, an opening capable of supporting and positioning the test substrate of the probe at a testing position. 45
9. The method of claim 8, wherein the shape of a test substrate of the probe is a disk. 50
10. The method of claim 1, wherein the test substrate of the probe is an integrated circuit having the same linear expansion coefficient with that of silicon in a temperature range of from 0°C to 200°C and the rigid substrate has a linear expansion coefficient of 1 ppm - 8 ppm in this temperature range. 55

Fig. 1 (a)

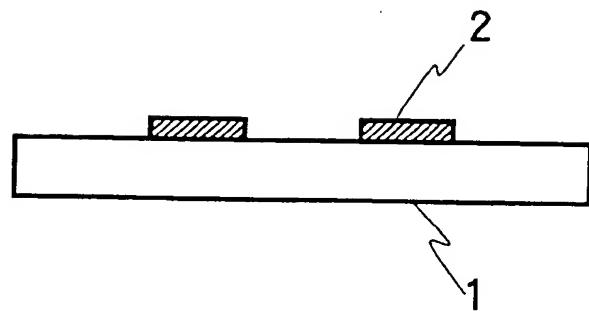


Fig. 1 (b)

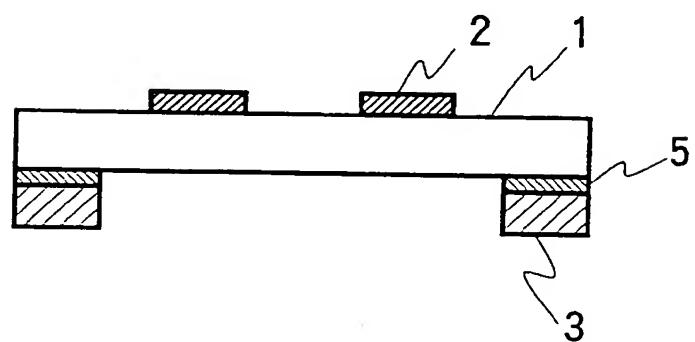


Fig. 1 (c)

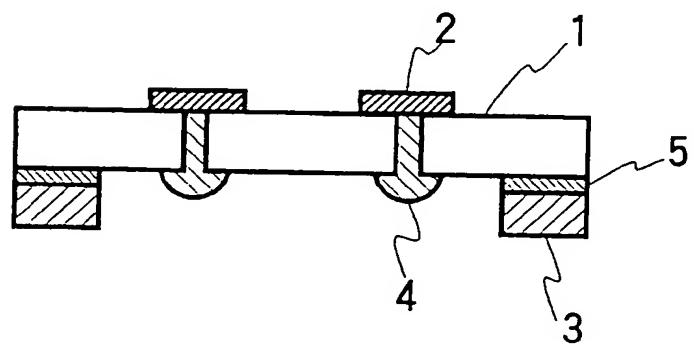


Fig. 2 (a)

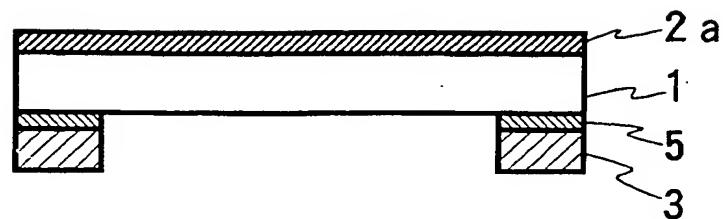


Fig. 2 (b)

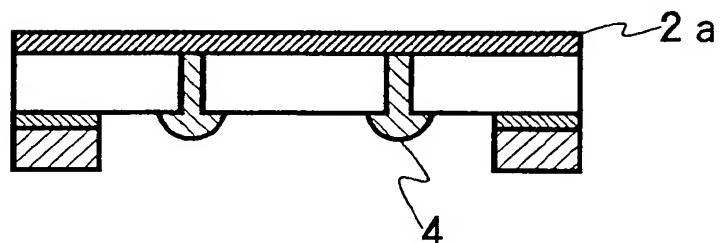
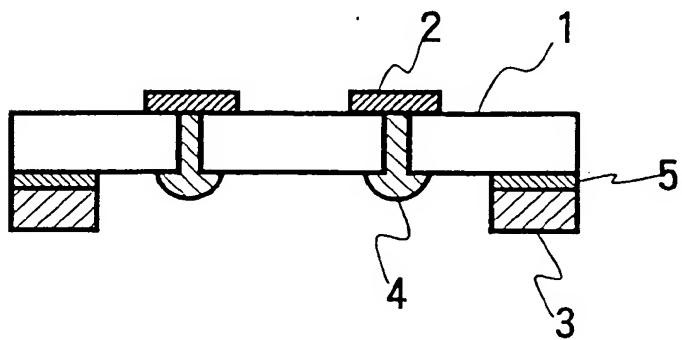
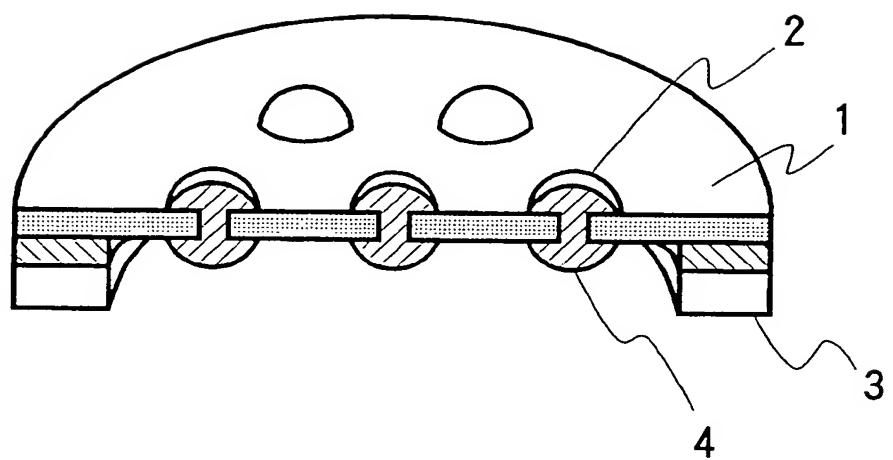


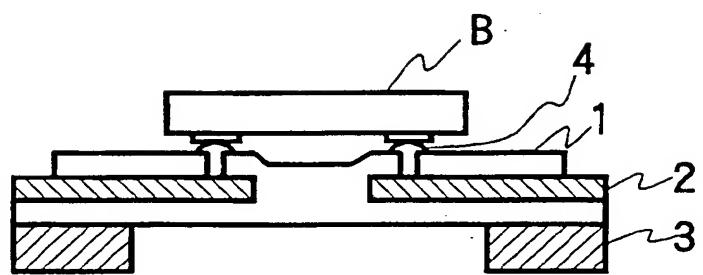
Fig. 2 (c)



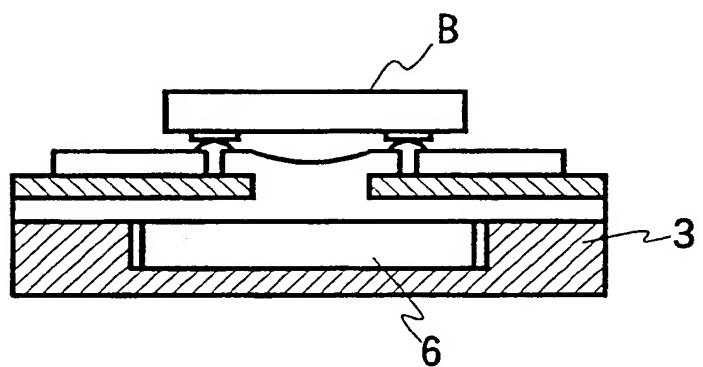
F i g. 3



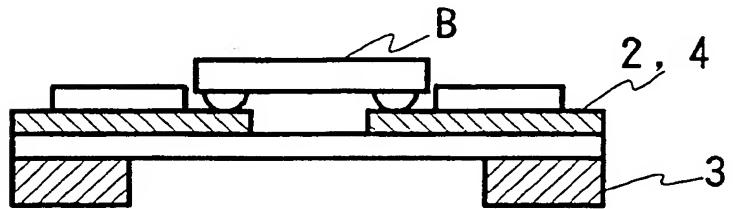
F i g. 4 (a)



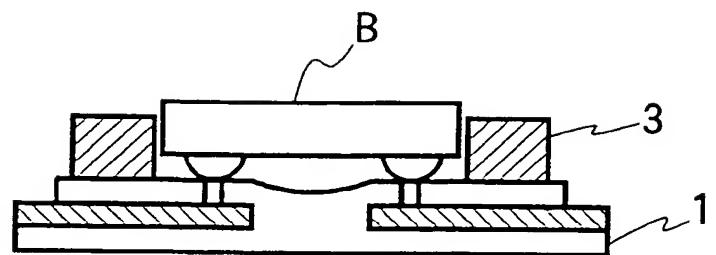
F i g. 4 (b)



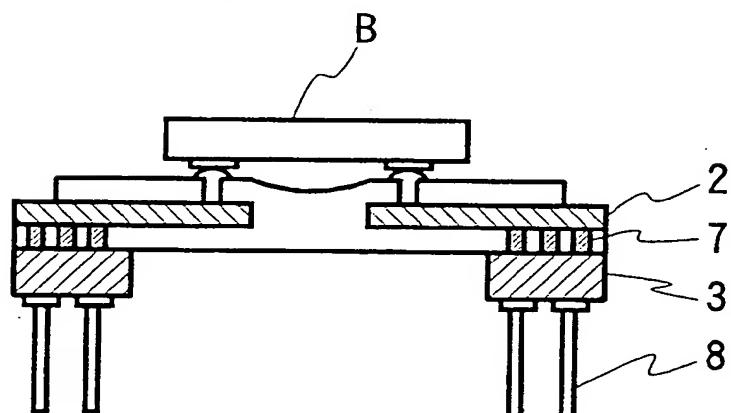
F i g. 4 (c)



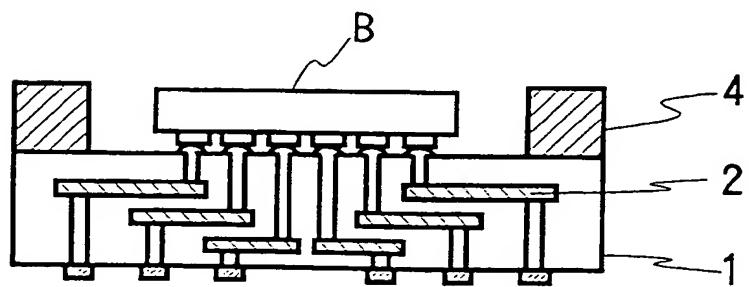
F i g. 5 (d)



F i g. 5 (e)



F i g. 5 (f)





(19)



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### (54) Method for fabrication of probe

(57) A method for fabrication of a probe, comprising the steps of: (1) forming a structure wherein a contact part formed on one side of an insulating flexible substrate and a conductor formed on either side or inside of said flexible substrate are electrically continued, and (2) joining said flexible substrate and a frame rigid substrate capable of supporting the tension in the planar direction of said flexible substrate at the outer periphery thereof, by bonding them by lamination press after heating, or by heating after lamination press, thereby applying a planar tension to the flexible substrate enclosed by the rigid substrate. According to the present invention, a method for fabrication of a probe can be provided, which probe serving well for use at high temperatures, such as for burn-in test, with high contact reliability, and being superior in durability as a test tool.

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European Patent  
Office

## EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.6)						
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim							
X	WO 93 06496 A (AINTILA) * page 5, line 1 - line 5 * ---	1	G01R3/00						
A	US 5 030 318 A (RECHE) * figure 1 * ---	1							
A	US 4 647 851 A (DUGAN) * figure 1 * ---	1							
A	EP 0 333 160 A (FURUKAWA DENKI KOGYO) * page 3, line 50 - line END * ---	1							
A	EP 0 484 141 A (HUGHES AIRCRAFT COMPANY) * claim 1; figure 1 * -----	1							
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)						
			G01R						
<p>The present search report has been drawn up for all claims</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Place of search</td> <td style="width: 33%;">Date of completion of the search</td> <td style="width: 34%;">Examiner</td> </tr> <tr> <td>THE HAGUE</td> <td>5 January 1998</td> <td>Hoornaert, W</td> </tr> </table>				Place of search	Date of completion of the search	Examiner	THE HAGUE	5 January 1998	Hoornaert, W
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THE HAGUE	5 January 1998	Hoornaert, W							
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